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The diurnal and seasonal variability of ice-nucleating particles at the High Altitude Station Jungfraujoch (3580ma.s.l.), Switzerland

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Cloud radiative properties, cloud lifetime, and precipitation initiation are strongly influenced by the cloud phase. Between similar to 235 and 273 K, ice-nucleating particles (INPs) are responsible for the initial phase transition from the liquid to the ice phase in cloud hydrometeors. This study analyzes immersion-mode INP concentrations measured at 243 K at the High Altitude Research Station Jungfraujoch (3580 m a.s.l.) between February 2020 and January 2021, thereby presenting the longest continuous, high-resolution (20 min) data set of online INP measurements to date. The high time resolution and continuity allow us to study the seasonal and the diurnal variability of INPs. After exclusion of special events, like Saharan dust events (SDEs), we found a seasonal cycle of INPs, highest in April (median in spring 3.1 INP std L-1) followed by summer (median: 1.6 INP std L-1) and lowest in fall and winter (median: 0.5 and 0.7 INP std L-1, respectively). Pollen or subpollen particles were deemed unlikely to be responsible for elevated INP concentrations in spring and summer, as periods with high pollen loads from nearby measurement stations do not coincide with the periods of high INP concentrations. Furthermore, for days when the site was purely in the free troposphere (FT), no diurnal cycle in INP concentrations was observed, while days with boundary layer intrusions (BLIs) showed a diurnal cycle. The seasonal and diurnal variability of INPs during periods excluding SDEs is within a factor of 7 and 3.3, respectively, significantly lower than the overall variability observed in INP concentration including SDEs of more than 3 orders of magnitude, when peak values result from SDEs. The median INP concentration over the analyzed 12 months was 1.2 INP std L-1 for FT periods excluding SDEs and 1.4 INP std L-1 for both FT and BLI, and including SDEs, reflecting that despite SDEs showing strong but comparatively brief INP signals, they have a minor impact on the observed annual median INP concentration.

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